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MEASURING THE PRODUCTIVITY OF FIRST-TERM NAVY ENLISTEES

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MEASURING THE PRODUCTIVITY OF MILITARY PERSONNEL

INTRODUCTION

Since the advent of the All-Volunteer Force (AVF) in 1973, the research community within the military has devoted much effort toward improving personnel management in the areas of accession and retention. Although not all factors have been quantified, we are able to estimate, with some accuracy, what draws and retains personnel of differing characteristics to the AVF. With knowledge of these factors, we can provide reasonable predictions of enlistments and reenlistments.

We know, for example, that our success in obtaining new recruits hinges largely on four factors: the ratio of military to civilian pay, the civilian unemployment rate, the number of recruiters, and the advertising budget. For predicting retention during the first term (hereafter referred to as survival probability), the most important factor is whether the enlistees are high school graduates or not. For estimating reenlistment rates, the main determinants are military pay relative to civilian pay, and the civilian unemployment rate.

We could refine our ability to forecast the supply of enlistees by collecting more reliable and up-to-date data or researching a broader range of variables beyond the purely economic ones. But the marginal benefits from such an effort seem small compared to the potential payoff of addressing more serious gaps in military manpower research.

The real gap is not in the supply side of the market. The side of the market that we do not understand is the demand side. Who should the Navy, or the overall military, seek to recruit and retain? How do military personnel substitute for each other? How do they enhance or reinforce one another? In short, we need to know what personnel are most individually productive and how different force configurations enhance or reduce military effectiveness.

About all we know with assurance about the factors that determine effectiveness are of those that influence first term attrition. Obviously a soldier who has left contributes nothing to military effectiveness, but the banality of this observation merely highlights our ignorance. There is no shortage of opinions of what makes military personnel effective. What we need, however, is statistical data—data to confirm or refute our intuition. Too often, though, we are stymied on how to measure military output.¹ In the few cases in which output can be measured, the data often exhibit such small variation in input measures that it is hard to draw precise conclusions on the effect of different input mixes on output.

¹ The exceptions are the estimates of the effects of maintenance activities on readiness, described by Horowitz, 1977. Unfortunately, only a small portion of military activities lend themselves to such easily identifiable output measures. Similar difficulties exist in the areas of education and medical care; more research, however, has been done in these areas.

In this paper, we analyze an unusual and largely unresearched data set, Rand Corporation's Enlisted Utilization Survey (EUS). Using data from the supervisors of Navy first-term enlisted personnel, we estimate the net productivity or learning curves of these personnel. Essentially we try to explain what factors make Navy recruits learn faster: ability, schooling, the particular job, or time on that job. This research on the determinants of individual productivity is but a first step in the analysis of the demand for military manpower. Still, we think our results are sufficiently provocative to warrant further research.

THE MEASUREMENT OF MILITARY OUTPUT

It is not surprising that the demand side of the market for military personnel has been neglected. First, there is no tangible output to measure. Second, since the military uses explicit fixed-length employment contracts, no one would suggest that an enlistee's current productivity is identified by his or her current wage.¹

Finally, the military gives recruits a considerable amount of training—some of it general and some of it specific. For example,

¹ Basic military pay, defined on pay tables, is determined by military rank and years of service. It rises very little over the first four years. In 1984, for example, the basic pay of enlisted personnel in their fourth year of service was 138 percent of the basic pay of new recruits. In addition to basic pay, there are other pays like housing allowances that depend on the individual's marital status.

nuclear-trained electronics technicians (6-year obligors) receive formal training after boot camp that involves 433 days of instruction and costs \$30,382; this job requires a 6-year active duty commitment.¹ Even for 4-year commitments, training costs are substantial; all recruits spend about 75 days in boot camp. The occupationally qualified then go to an "A-school" for formal training of varying length. For example, non-nuclear electronic technicians spend 240 days at A-school, radiomen spend 126 days, and machinists mates spend 74 days.

A significant application of this work is on the length of the initial employment contract. Currently, Navy contracts vary from 4 to 6 years with the training-intensive nuclear occupations having 6 year, a small bunker of occupations 5 year, and the majority of Navy jobs 4 year initial employment contracts. Fixed-length-explicit-employment contracts are found very rarely in the civilian economy yet they are the norm in the military. An understanding of occupation-specific learning curves should stimulate research into occupationally optimal first term enlistment lengths as well as into the more theoretical question of why employment contracts differ so sharply between the two sectors.

In the private economy, individuals usually pay for their training. The payment may be direct (college tuition, for example) or indirect (lower wages when an employer provides the training). Indeed on-the-job

¹ These are formal instruction costs and wages while in training (1979 dollars). See Angier and Driscoll, 1982.

training (OJT) in the civilian sector is often identified with the slope of the earning/experience profile. Occupations with large components of OJT have steeper profiles than occupations with smaller amounts of "learning of the job."

An explicit employment contract in the military clearly breaks the linkage between spot marginal product and spot productivity. Lazear (1981) and others argue that the link is broken even in the civilian sector. Implicit contracts between private-sector employees and their firms are sufficiently pervasive as to make it impossible to relate earnings profiles to the time path of productivity. In fact, attempts to test the theory that wages reflect marginal productivity (see Medoff and Abraham (1981)) find that there are substantial discrepancies.

In a world of fixed length employment contracts, either explicit or implicit, how can researchers measure the productivity of employees? We offer one approach here. The population we analyze is a cohort of first-term Navy personnel. At this juncture, it is appropriate to turn to a discussion of our data.

THE DATA

In 1975 the Rand Corporation conducted a survey project for the Defense Advanced Research Project Agency, intended to measure the growth of productivity over the first enlistment term. (For a full description

of these data, as well as an analysis of the appropriate mix of first-term and second-term personnel for the Air Force see Albrecht, 1979.) The project involved two surveys, First, a set of military occupations were chosen to represent the spectrum of skills required by the services. Then, 19,000 first-term enlistees from these skill areas in the Air Force, the Army, and the Navy were randomly selected from service personnel files. These individuals were sent questionnaires that requested the names of three immediate supervisors as well as background information not found on service personnel records. (The questionnaires are available from the authors of this paper.) The response rate was 72.9 percent, resulting in a total of 6,558 questionnaires that identified individuals' supervisors.

Next, net productivity estimates were collected from these supervisors. The questionnaire used for this survey included a brief discussion of the concept of net productivity,¹ an implicit test of whether the supervisor understood the concept, and questions about the trainee's net productivity at different points in time. All net productivity assessments were relative: the net productivity of the trainee at time t relative to the net productivity of the average specialist within the occupation after 4 years at the duty station. The

¹ Net productivity is the contribution of the trainee to unit output. It is negative if the trainee and the supervisor together produce less than the supervisor would have produced responsibility for training the individual.

supervisors returned 7,110 questionnaires, 75.4 percent of those mailed to correct addresses.¹

Before discussing our empirical results, it is appropriate to address the problems caused by biases in the supervisory evaluations.

The Problems of Biases

The first type of bias arises from the inherent subjectivity of supervisor's evaluations. They reflect individual tastes, performance standards, and perceptions of the performance of others. Nevertheless, if the assignment of individuals to supervisors is random and if the sample is large, there will be no systematic evaluation bias. Given that Navy supervisors have little or no influence over the particular trainees assigned to them, it seems reasonable to characterize the assignment of Navy trainees to supervisors as random. Since we also have large numbers of observations, we believe this form of bias is unimportant.²

¹ Because of job changes and misspelled names, 13 percent of the supervisor questionnaires were not deliverable.

² In technical terms, this type of supervisory subjectivity will reduce the accuracy of the resultant estimates. Although coefficient estimates are unbiased, their standard deviations will be larger than they would be in a world of homogeneous supervisory tastes.

A second type of bias is potentially more serious. It arises from the fact that each supervisor denominates his evaluation in his own particular currency. In fact, the existence of this bias essentially halted analysis of the survey data at the Rand Corporation. Richard Cooper and Gary Nelson, 1976, perceive two sources of this systematic bias. First, supervisors may differ on "location." Some of them may rate average performance as a "C" while others perceive "B" work as average. Second, supervisors may differ in perception of "scale." Some perceive large differences between their best and worst performers, while others see only small differences.

Cooper and Nelson showed that biases created by systematic differences in scale and location do not disappear, even with large sample sizes. They concluded that "although the location bias can be handled in multiple regression models through familiar dummy variable techniques, the scale bias poses special estimation problems." They proposed a multi-scale model and a complex strategy that involves choosing among complicated estimation strategies on the basis of Monte Carlo experiments. Unfortunately, the data do not contain enough multiple observations (supervisor "X" rating several enlistees and enlistee "Y" being rated by several supervisors) to make their techniques practical.

An Alternative Approach

A simpler and more appealing approach would be to recognize that supervisors have systematic differences in the scale and location of their evaluations. Then, if we can measure these systematic biases of supervisors and then control for them in the productivity regression equations. With such controls, we could estimate the true effects of time on the job, education, and ability, on productivity growth without bias. A close look at the rich data in the EUS suggests that it might be possible to construct variables that would control for supervisory location and scale bias.

In particular, the EUS asked each supervisor to evaluate the typical A-school trainee in each rating at several points: after one month, after 2 years, and after 4 years at the first duty station.¹ Productivity was measured relative to the average fourth-year specialist in the Navy rating. Using these supervisor's assessments, we computed supervisory bias control variables for location (DIFF) and scale (VAR).

Specifically for each of the 15 jobs, consider an individual, i , with a supervisor, j . Let TYP_j be supervisor j 's assessment of the

¹ Supervisors were asked these questions twice: once for the typical A-school trainee in their rating, and once for the typical on-the-job trainee in their rating. To compute our control variables, we used the appropriate supervisory assessment (formal schooling (A-school) or on-the-job (OJT)).

typical trainee at time t, and \overline{TYP} be the mean assessment of supervisors in that rating of the typical trainee at time t. Then, for each individual

$$DIFF_i = TYP_j(2 \text{ years}) - \overline{TYP}(2 \text{ years})$$

$$VAR_i = \frac{TYP_j(1 \text{ month}) - TYP_j(4 \text{ years})}{\overline{TYP}(1 \text{ month}) - \overline{TYP}(4 \text{ years})}.$$

Location bias is a shift effect and can be proxied simply by the constructed variable DIFF. (The sign on DIFF should be positive. Supervisors who believe that the typical trainee is more productive than their peers believe him to be will also tend to rate particular individuals as more productive.)

Scale bias, on the other hand, refers to perceived differences (larger or smaller) between the best and the worst performers. Individuals who have a large value of VAR have been evaluated by supervisors who see large differences in the growth of the typical trainee over the first 4 years at the duty station; small individual values of VAR are evaluations by supervisors who perceived less change in the productivity of the typical trainee over the same period. To capture this scale effect, then, it is necessary to enter both VAR and VAR interacted with time at the duty station into the equation: the

sign on VAR should be negative, and the sign on the interaction variable (VARTJ) should be positive.¹

EMPIRICAL WORK

The Learning Curve Regressions

We begin by estimating the time path of net productivity (or learning curve) for first-term trainees. Each observation involves an individual and his or her supervisor at a particular time at the first duty station. All regression results are estimated by ordinary least squares.

Initial inspection of the data revealed that some individuals were not first-termers (some were Reservists and some were second-termers); these observations were excluded. Additionally, we selected only the observations in which the supervisor said he was familiar with the work of the trainee.

Regression equations were developed separately for each of the 15 Navy occupations surveyed. They control for time at the duty

¹ Supervisors who perceive large variances in productivity essentially see a steeper slope in the productivity profile. In short, they perceive individuals beginning as quite unproductive (the negative sign on VAR) and then having fast productivity growth (the positive sign on VARTJ).

station, time in the Navy before the first duty station, AFQT score, high school education, supervisor's understanding of net productivity, supervisory bias, and missing observations.¹ In addition, they control for individuals who initially were assigned to an occupation but failed technical training school and were assigned to general detail jobs (AN, SN, FN). Variable definitions are found in Table 1.

The full individual learning curve regression results are displayed in table 2. The corrections, (DIFF, VAR, VARTJ) developed to control for systematic differences across supervisors in the location and scale of their evaluations perform very well. All have the correct sign and all are significant at the 99 percent level. The variable TEST is positive and statistically significant in 14 of 15 regression equations. It has the value one if the individual did not pass the net productivity concept quiz, otherwise it is zero. Supervisors who did not understand the concept systematically rated the productivity of their trainees higher than did supervisors who understood the concept.²

¹ Some observations had missing data--in particular, AFQT, DIFF, and VAR. Rather than exclude them entirely, we assigned the mean value of the variable. We then flagged these observations with dummy variables (AFQTFLAG, DIFFFLAG, and VARFLAG). With this procedure, the coefficients on AFQT, DIFF, and VAR reflect only the real observation of these variables, with the coefficients on AFQTFLAG, DIFFFLAG, AND VARFLAG reflecting the missing observations. In general, the coefficients on these "flag" variables cannot be interpreted unambiguously.

² Regressions that omit observations if the supervisor did not understand the concept of net productivity are available from the authors of this paper. The results are similar to the regressions reported here.

TABLE 1
DEFINITIONS OF VARIABLES

Dependent Variable

Net Productivity: Supervisor's evaluation of individual's net productivity relative to that of a specialist with 4 years of experience

Independent Variables

TJ: months at the first duty station

TJSQ: (TJ)(TJ)

AFQT: Armed Forces Qualifications Test score. This intelligence test is routinely administered to all recruits

HSG: One if high school diploma graduate, else zero

T: Months in Navy before arrival at first duty station

DIFF: Difference between supervisor's perception of the average individual and the average supervisor's perception of average (see text)

VAR: Measure of the average variability perceived by this supervisor and the overall average variability (see text)

VARTJ: (VAR)(TJ)

TEST: Dummy variable with the value of one for supervisors who did not understand the concept of net productivity, else zero

FLUNK: A dummy variable for individuals who flunked technical school (only relevant for general-duty personnel who are not occupationally qualified)

Control Variables for Missing Information

These variables have the value 1 if the relevant independent variable are missing. Missing variables are assigned variable means.

AFQTFLAG: AFQT scores are missing for about one-third of the non-occupational qualified personnel. For the 10 occupations, missing values vary from zero to 15 percent.

DIFFFLAG: Missing values vary from 8 to 29 percent by job.

VARFLAG: Missing values vary from 12 to 38 percent by job.

TABLE 2
NET PRODUCTIVITY REGRESSIONS

| | Nuclear submarine occupations ^a | | |
|----------------|--|---------------------------------|-------------------------------------|
| | Machinist's Mate (MM 3355) | Electrician's Mate (EM 3354) | Electronics Technician (ET 3353) |
| TJ | 3.04 (12.2) | 3.30 (11.8) | 3.09 (10.2) |
| TJSQ | -.05 (16.9) | -.05 (13.7) | -.06 (14.4) |
| AFQT | .06 (.9) | .19 (2.0) | .39 (4.7) |
| T | 1.24 (11.6) | .95 (9.1) | 1.06 (7.7) |
| TEST | 9.50 (4.4) | 4.40 (1.9) | 8.40 (2.9) |
| DIFFFLAG | 3.78 (1.1) | 16.98 (3.0) | -9.40 (1.9) |
| VAR | -53.67 (9.5) | -48.08 (7.9) | -57.58 (8.6) |
| VARFLAG | -.87 (.3) | -13.62 (2.4) | 10.37 (2.2) |
| VARTJ | 1.77 (9.4) | 1.29 (6.2) | 2.03 (9.0) |
| DIFF | .39 (12.9) | .35 (8.1) | .25 (5.7) |
| Constant | -.80 | .84 | -25.38 |
| R ² | .57 | .54 | .60 |
| # Obs. | 2238 | 1591 | 1357 |

^a Since there were no missing observations on AFQT, AFQTFLAG is not included in these regressions. Similarly, HSG does not appear in the nuclear rating regressions since all individuals were high school graduates.

TABLE 2 (Cont'd)

| | Other occupations | | |
|----------------|--------------------------------|----------------------------|--|
| | Electronics Technician (ET) | Electrician's Mate (EM) | Aviation Electrician's Mate (AE) |
| TJ | 3.50 (15.9) | 2.99 (19.6) | 3.62 (4.7) |
| TJSQ | -.06 (18.4) | -.05 (21.5) | -.06 (5.5) |
| AFQT | .08 (1.2) | .002 (.1) | .50 (2.6) |
| AFQTFLAG | 1.32 (.2) | 21.32 (4.3) | N.A. |
| HSDG | 11.54 (4.0) | 4.23 (2.5) | -5.24 (2.6) |
| T | .53 (9.2) | .88 (5.2) | .40 (1.5) |
| TEST | 7.00 (3.8) | 4.14 (3.3) | -4.93 (.7) |
| DIFFFLAG | -1.04 (.1) | .60 (.1) | 35.15 (4.3) |
| VAR | -37.08 (9.5) | -41.33 (17.0) | -81.78 (4.9) |
| VARFLAG | -.15 (.0) | -1.48 (.4) | N.A. |
| VARTJ | 1.48 (10.4) | 1.51 (17.3) | 1.49 (2.7) |
| DIFF | .33 (11.1) | .58 (26.0) | .78 (8.7) |
| Constant | 2.72 | 26.78 | 27.03 |
| R ² | .47 | .53 | .64 |
| #Obs. | 2948 | 4263 | 200 |

TABLE 2 (Cont'd)

| | Other occupations | | |
|----------------|----------------------|----------------------------------|---|
| | <u>Radioman (RM)</u> | <u>Machinist's Mate (MM)</u> | <u>Aviation Machinist's Mate (AD)</u> |
| TJ | 3.67 (20.4) | 2.73 (14.4) | 3.02 (6.1) |
| TJSQ | -.06 (23.6) | -.05 (15.8) | -.06 (7.4) |
| AFQT | .16 (3.8) | .18 (4.2) | -.02 (.2) |
| AFQTFLAG | 1.34 (.7) | 12.50 (1.5) | 10.88 (1.9) |
| HSDG | 3.55 (2.3) | 5.90 (3.5) | .37 (.1) |
| T | .50 (6.9) | .73 (10.8) | .11 (.7) |
| TEST | 5.36 (3.7) | 9.68 (5.7) | 9.08 (2.4) |
| DIFFFLAG | -3.88 (.7) | 2.64 (.6) | 25.26 (1.7) |
| VAR | -38.12 (13.1) | -34.71 (10.4) | -48.40 (5.3) |
| VARFLAG | 7.55 (1.4) | -3.58 (.8) | -4.77 (.4) |
| VARTJ | 1.46 (13.9) | 1.35 (11.4) | 1.62 (5.1) |
| DIFF | .54 (21.7) | .42 (16.2) | .46 (6.0) |
| Constant | 17.06 | 4.59 | 51.78 |
| R ² | .54 | .46 | .48 |
| #Obs. | 3071 | 3545 | 453 |

TABLE 2 (Cont'd)

| | Other occupations | | |
|----------------|---------------------------------------|----------------------------|---------------------------|
| | Mess Management Specialist (MS) | Dental Technicians (DT) | Hospital Corpsman (HM) |
| TJ | 2.05 (8.5) | 1.63 (7.0) | 2.29 (8.0) |
| TJSQ | -.03 (7.1) | -.03 (6.9) | -.04 (9.6) |
| AFQT | .25 (3.6) | -.11 (1.8) | -.02 (.3) |
| AFQTFLAG | 8.22 (1.7) | 8.11 (2.7) | 2.64 (.8) |
| HSDG | 4.92 (2.3) | 6.11 (1.3) | 3.92 (1.2) |
| T | .87 (2.8) | .43 (4.6) | -.45 (3.7) |
| TEST | 9.85 (4.8) | 8.40 (3.6) | 14.37 (3.0) |
| DIFFFLAG | -13.32 (2.6) | -1.88 (.2) | -18.14 (3.0) |
| VAR | -31.36 (10.0) | -29.93 (8.7) | -29.50 (6.2) |
| VARFLAG | 10.36 (2.3) | -9.11 (1.1) | 14.17 (2.5) |
| VARTJ | .81 (7.3) | .95 (8.4) | 1.23 (7.3) |
| DIFF | .58 (7.3) | .51 (12.4) | .35 (8.9) |
| Constant | 18.43 | 66.35 | 58.77 |
| R ² | .34 | .38 | .33 |
| #Obs. | 2422 | 1168 | 1488 |

TABLE 2 (Cont'd)

| | General-duty personnel | | |
|----------------|------------------------|--------------------|---------------------|
| | <u>Seamen (SN)</u> | <u>Airmen (AN)</u> | <u>Firemen (FN)</u> |
| TJ | 2.13 (8.1) | 2.53 (7.3) | 1.88 (5.4) |
| TJSQ | -.04 (8.7) | -.04 (7.5) | -.03 (5.9) |
| AFQT | .18 (2.2) | .29 (2.5) | .32 (3.2) |
| AFQTFLAG | -.48 (.2) | -1.94 (.5) | -13.89 (3.2) |
| HSDG | 6.93 (3.2) | 9.38 (3.2) | -1.74 (.6) |
| T | .53 (2.3) | .19 (.6) | .24 (.7) |
| TEST | 8.57 (4.0) | -2.94 (1.0) | 15.47 (5.3) |
| DIFFFLAG | -12.36 (1.9) | -16.41 (1.1) | 13.56 (.9) |
| VAR | -39.98 (8.8) | -36.35 (6.8) | -36.41 (6.1) |
| VARFLAG | 13.47 (2.2) | 13.98 (1.0) | .45 (.0) |
| VARTJ | 1.31 (8.5) | 1.29 (6.8) | 1.48 (7.1) |
| DIFF | .63 (18.2) | .50 (10.5) | .47 (9.8) |
| FLUNK | -7.16 (3.0) | -10.20 (2.7) | -4.31 (1.2) |
| Constant | 27.13 | 24.37 | 16.69 |
| R ² | .40 | .47 | .45 |
| #Obs. | 2072 | 839 | 933 |

Note: Numbers in parentheses beneath coefficients are the absolute values of the t statistics.

Net productivity is -100 percent if the individual requires full-time supervision by a 4-year specialist, +100 percent if the individual is as productive as a specialist with 4 years of job experience. This grows over time. After 4 years of experience, most regressions predict that the average individuals in our sample achieve the 100-percent level of a typical specialist. (The exceptions are in the general-duty jobs, where the concept of a 4-year specialist is obscure.)

The results naturally lead to two areas of discussion: the time path of productivity, and the effects of personal characteristics on the level of productivity.

The Time Path

Even a cursory inspection of these results suggests that Navy personnel take considerable time to learn their jobs and become productive. Moreover, reasonably sharp differences in the rate of growth of learning emerge. While the average seaman (without specialized training) is expected to arrive at his first duty station after about 2.5 months in the Navy, the average nuclear electronics technician, because of extensive schooling, is not programmed to arrive at his first duty station until almost 17 months after entering the Navy. (Because of waiting time, travel, leave, or other exigencies, programmed arrival probably understates the time it takes an enlistee to reach his first duty station. Moreover, at the time of the EUS survey

it was common to send some individuals to sea for a short period before they began classroom instruction. Thus, in our data, the average time until arrival at the first duty station is probably longer than planned training pipelines.)

Figure 1 illustrates the learning curves for nuclear electronics technicians (ETs) and general-duty seamen (SNs). The curves are drawn for high school graduates having mean AFQT scores within the occupation (83.0 for nuclear-trained ETs and 56.6 for SNs). Time in the Navy prior to arrival at the first duty station (T) is assigned the current programmed values. Other variables in the regression (except for those that relate to TJ) are assigned mean values.

While an SN after 2 years in the Navy is almost 70 percent as effective in his job as one with 4 years of experience, a nuclear ET with 2 years in the Navy has only reached the zero net productivity level. In short, the nuclear ET has reached the point at which his contributions to output just balance the output lost because supervisors must spend time supervising him.

Because the ET's training takes so long, during his his entire 6-year enlistment he produces less than a third of the output that would have been produced by a specialist with 4 years of work experience. Moreover, these figures, and the regressions from which they are derived, abstract from both formal training costs and attrition. As

suggested earlier, for a nuclear ET graduate in 1979 these training costs were more than \$30,000.

While figure 1 contrasts the two ends of the spectrum, table 3 illustrates the entire spectrum of results—all the Navy occupations in the EUS survey. (These occupations cover about half of Navy enlisted personnel.) For technical Navy jobs, individuals contribute nothing to output when they first arrive at their duty stations. Apparently, considerable on-the-job training is necessary before they can contribute to output. (For occupationally-qualified personnel, exceptions to this pattern are less skilled personnel (AD and MS) and medical personnel (DT and HM).) Why medical specialties involve less on-the-job training is unclear. Perhaps a smaller proportion of them are assigned to operational units and therefore do not receive extensive shipboard orientation. Then too, these jobs may require more individual-specific skills rather than a range of skills. Overall, in fact, we are least successful in predicting productivity for the medical specialties.

Interestingly enough, net productivity levels are reasonably similar across the ratings after individuals have been at their duty station for 2 years. However, these similarities, as we have noted, mask important differences across the occupations in how long individuals have been in the Navy: in the EUS data, individuals in the three nuclear occupations were in the Navy over 4 years, individuals in other occupations were in the Navy 2-1/2 to 3-1/2 years, and general

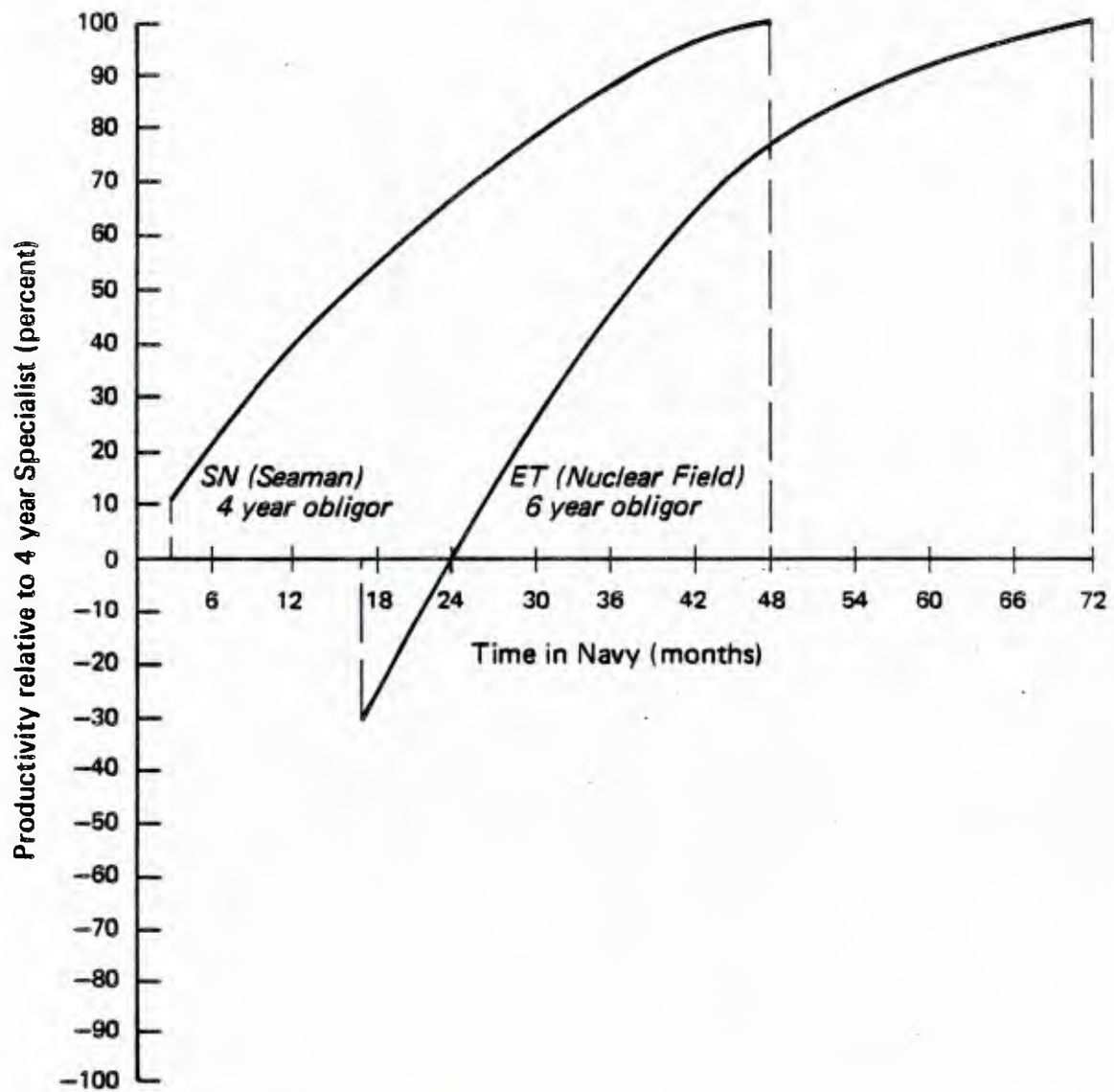


FIG. 1: THE TIME PATH OF PRODUCTIVITY OVER THE FIRST ENLISTMENT TERM

TABLE 3

PRODUCTIVITY TIME PATHS^a

| | Submarine nuclear occupations | | | Other occupations | |
|---|-------------------------------|---------------------------------|-------------------------------------|--------------------------------|----------------------------|
| | Machinist's Mate (MM 3355) | Electrician's Mate (EM 3354) | Electronics Technician (ET 3353) | Electronics Technician (ET) | Electrician's Mate (EM) |
| <u>Characteristics of Rating</u> | | | | | |
| Current planned pipeline length | 11.4 mo. | 13.1 mo. | 16.9 mo. | 10.5 mo. | 6.7 mo. |
| Average months in EUS data before arrival at duty station | 27.1 mo. | 31.1 mo. | 32.6 mo. | 16.1 mo. | 8.8 mo. |
| <u>Net productivity</u> | | | | | |
| - When arrive at duty station | -11.5% | 0% | -13.9% | -6.4% | -0.5% |
| - After 2 yrs at duty station | 73.1% | 80.4% | 76.3% | 78.0% | 77.0% |
| - After 4 yrs at duty station | 96.0% | 101.7% | 101.1% | 99.7% | 95.1% |

TABLE 3 (Cont'd)

| | Other occupations (Cont'd) | | | | | | |
|---|---------------------------------------|------------------|-------------------------|-------------------------------------|------------------------------------|-------------------------------|------------------------------|
| | Aviation Electricians Mate (AE) | Radiomen (RM) | Machinists Mate (MM) | Aviation Machinists Mate (AD) | Mess Management Specialist (MS) | Dental Technicians (DT) | Hospital Corpsmen (HM) |
| <u>Characteristics of rating</u> | | | | | | | |
| Current planned pipeline length | 7.0 mo. | 5.4 mo. | 5.0 mo. | 4.3 mo. | 4.0 mo. | 5.2 mo. | 5.0 mo. |
| Average months in EUS data before arrival at first duty station | 16.1 mo. | 12.5 mo. | 11.9 mo. | 12.8 mo. | 6.1 mo. | 14.1 mo. | 17.9 mo. |
| <u>Net productivity</u> | | | | | | | |
| - When arrived at duty station | -19.1% | .4% | -1.5% | 13.5% | +13.3% | 44.7% | 27.8% |
| - After 2 yrs at duty station | 69.7% | 85.7% | 69.3% | 91.8% | 65.2% | 89.8% | 86.9% |
| - After 4 yrs at duty station | 92.6% | 95.4% | 87.7% | 106.2% | 83.6% | 102.6% | 97.5% |

TABLE 3 (Cont'd)

| | General duties | | |
|---|----------------|-------------|--------------|
| | Seaman (SN) | Airmen (AN) | Firemen (FN) |
| <u>Characteristics of Rating</u> | | | |
| Current planned pipeline length | 2.5 mo. | 2.5 mo. | 2.5 mo. |
| Average months in EUS data before arrival at first duty station | 5.2 mo. | 5.5 mo. | 4.6 mo. |
| <u>Net Productivity Estimates</u> | | | |
| - When arrive at first duty station | 6.4% | 7.3% | 2.4% |
| - After 2 yrs at duty station | 62.0% | 75.2% | 61.3% |
| - After 4 yrs at duty station | 83.4% | 95.7% | 85.3% |

^a Regression coefficients are from regressions found in table 2. The coefficient on TJ is the sum of the coefficient on TJ and VARTJ (with evaluated at its mean value). Net productivity evaluations are calculated for the mean characteristics of individuals in the Navy job.

duty personnel were in the Navy about 2-1/2 years before they had 2 years at a duty station.

Effects of Individual Characteristics on Productivity

While higher AFQT scores and high school graduation appear to be positively related to productivity, the magnitude and statistical significance of many of the effects are not as large as we had hypothesized. This should not be surprising. Since the allocation of recruits to Navy jobs is not random and is based on many of the same characteristics that influence performance, estimates that do not account for this may be downwardly biased. (We expect, for example, that the OLS estimates of the effects of AFQT and education will be too low). Unbiased estimates can be obtained by controlling for the occupational selection process.

Unfortunately, standard techniques to control for this "selection bias" are not appropriate. In particular, for mid-skill-level Navy jobs the ability and schooling distributions are truncated on both the upper and lower tails. Statistical models to control for double truncation bias might lead to larger estimates. Thus the generally small magnitude of these results for quality should be interpreted cautiously.¹

¹ See Heckman, 1979, for a discussion of a more straightforward problem of selection bias. Double truncation bias is considerably more difficult to implement empirically.

We do know that high school graduates and individuals with higher AFQT scores are considerably more likely to complete the first enlistment term than are not-high-school graduates and individuals with low scores. In short, the necessary condition for the production of military output--the presence of the individual--is importantly related to measures of personnel quality, but as we noted before, this provides limited insight into the issue of actual performance.

Finally, for general-duty personnel, we know whether or not they attempted to become rated (occupation-qualified) but failed technical school. Conventional Navy wisdom suggests that individuals who fail technical school will be unhappy with their status and, thus, less productive. The regression results support this position: productivity levels are lower for people who failed technical training.

IMPLICATIONS AND CONCLUSIONS

Acquiring skills takes considerable time in many Navy jobs. To some extent, current Navy contract lengths reflect that fact. There is no evidence, however, that the length of these contracts has been set systematically by occupational specialty so that output could be achieved at least cost. Thus, one natural outgrowth of this research on occupational learning curves would be an investigation of initial enlistment contract length.

It may be that the Navy could use changes in contract length by occupational specialty to generate the same output at lower cost. Determination of the appropriate contract length for the different occupations requires information on pay and training costs and productivity profiles. With them, the period of time necessary for the Navy to recoup its investment (or some fraction thereof) can be calculated.

However, supply problems must also be considered. With longer contracts, higher pay is required to attract the same number of individuals. Also, longer contracts may be characterized by higher early attrition. Thus, any recruiting, training, and career force cost savings from lengthening initial enlistment contracts must be weighed against costs of increased pay and attrition. Some assumptions will have to be made because existing data do not allow empirical estimation of all the important variables. However, existing information should permit a worthwhile examination of the costs and benefits of varying first-term enlistment lengths.

A key policy variable related to the growth of productivity during a career in the Navy is the mix between careerists and first-termers. The Navy and Air Force have traditionally had larger proportions of experienced personnel than have the Army and the Marine Corps. In 1980, over 42 percent of Navy and Air Force enlisted personnel were in the top five paygrades (E-5 through E-9), compared to 36 percent of the Marine

Corps and Army. Moreover, the differences among the services are really concentrated in middle grades (E-5 through E-7): the Navy and Air Force have 6 percent more of their enlisted force in these paygrades than do the Army and the Marine Corps. The Navy, moreover, plans to expand the proportion of experienced personnel (those with more than 4 years experience).

To address issues of who the military should recruit, who the military should retain, and how the military should distribute these personnel, much more work on the demand side is necessary. If we are to address the demand side of personnel questions with the degree of sophistication with which we address supply questions, we need to think hard about what data we need and whether experimental data are required.

This is an area of research that is of interest to labor economists within and without the military research community. The relationship of experience and personnel characteristics to marginal productivity, and of productivity to wages and wage contracts is not well understood. This work represents an initial step to explore this issue, but a substantial research agenda remains.

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